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INJURIOUS INSECTS AND DISEASES OF PLANTS WITH REMEDIAL
MEASURES FOR THE SAME.

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INJURIOUS INSECTS AND DISEASES OF PLANTS WITH REMEDIAL MEASURES FOR THE SAME.

Notwithstanding the numerous publications from Agricultural Experiment Stations, Departments of Agriculture, both State and National, and in the *Agricultural Press*, there is a constant demand upon us by letter for information upon these two somewhat kindred subjects. This has led us to prepare the following data in popular form, selected from the studies and experiments of this and other like institutions.

It is intended that this bulletin shall be introductory in character, giving information for which there is a constant demand. If it shall reach those directly interested and bring them into communication with the Station to the end that our work be furthered and they benefited, it will have accomplished the desired purpose.

The Station desires to obtain from farmers and growers throughout the State information concerning the injurious insects and destructive diseases of plants with which they are brought in contact. In return, we will furnish such information concerning injurious species and their treatment as may be possible. Further, the Station desires to study injurious species of insects and fungi and make experiments in treating the same, when treatment is not known, if their importance will warrant such work. In doing local work of this character, growers can often be of very material assistance and have the advantage of becoming practically familiar with methods of conducting experiment work. Prompt information sent to the Station concerning injurious species, may result in preventing serious loss.

When writing for information on these subjects, the letter should be accompanied with specimens of the plants being injured, and if the injury is caused by insects, specimens should be

sent. Insects should be put in a strong, small box of wood or metal, accompanied by some of their food, neatly wrapped and addressed to the Station. In addition to the address put on the outside of the box, the words, "Specimens from ——" (giving the name of the sender). This last precaution is very important, as it enables the specimens to be at once placed with the letters giving information concerning them.

Seidlitz powder boxes and small baking powder boxes are excellent for sending specimens. Holes should not be punched in the boxes. Insects will live for several days if accompanied with a portion of their food plant. Writing must not be put in the packages containing specimens, as it then becomes subject to letter postage. Dry specimens of insects can be safely sent in a pill box packed with cotton. There is little danger of sending too many specimens, but, when possible, not less than a dozen should be sent. Specimens of plants can usually be safely sent in an ordinary envelope or wrapped between card-board. A full account of injurious species is always of importance and should be given when possible.

I. SOME INJURIOUS INSECTS.

No effort is made in this bulletin to treat fully of the many injurious insects which prey upon the farmers' crops, but merely to characterize, as briefly as possible, a few of the most common species, hoping in this manner to enable farmers to recognize them sufficiently well to apply the remedies prescribed. Anything like a complete treatise does not come within the scope of station work, nor is there demand for such an undertaking, as several works on this subject are sold within the means of all farmers. Probably the most complete which might be mentioned, are Packard's "Entomology for Beginners," and Saunders' "Insects Injurious to Fruits."

However, the remedial measures prescribed in some cases in the above named works, are valueless.

To avoid much repetition, the remedial preparations are discussed in a separate section of this bulletin.

Plant Lice (*Aphides*).

These are small, variously colored, soft bodied insects, occurring in both winged and wingless forms. They have no biting jaws, but are provided with a proboscis or sucking tube which they insert through the epidermis of the soft parts of the plants and extract the sap, thus causing the parts to wither, in many instances to die. If on the foliage, the leaves curl up and assume a sickly appearance, falling prematurely. On the roots, they cause galls or knotted swellings, doing much injury, as the apple root louse.

These insects have a most interesting life history, that of many of the species being not yet well known. They alternate between egg-laying and viviparous females. The latter form occurs during the warm season and brings forth young very rapidly, averaging, in mature individuals, two to six per day, thus their power to do harm is simply enormous as compared to their size. The young reach maturity in from four to twelve days, varying with temperature and species. The root louse of the grape (*Phylloxera*) does not belong to this family but is closely related, and should be treated as for apple root louse.

Remedies.—Treat with kerosene, soap or lye washes, as given under those heads.

Species of plant lice infest apple, peach, plum, cherry, cabbage, etc.; in fact, there are few cultivated plants which are not under one circumstance or another attacked.

Warm, moist weather aids in their rapid multiplication. The small beetles, known as the lady birds, destroy many plant lice and thus aid much in holding them in check, hence should not be destroyed.

Scale Insects or Bark Lice (*Coccids*).

These insects are members of the same group (Homoptera) as the Aphides, and are like them in some points especially in the manner of taking food.

They attach themselves while young to the bark of the plant or epidermis of the leaf, and there remain permanently fixed, secreting a scale, which protects them from ordinary injury. The female remains in this position, producing, when mature, a

greater or less number of eggs, from which young are hatched later.

Well known examples of these insects are the bark lice of the apple, the peach scale, etc.

The scale covering these insects makes them somewhat difficult to treat, but they can be reached by various means.

Remedies.—Care should be taken to observe when the young are hatching and spreading over the plant, and treat them with kerosene or lye washes as mentioned under those headings. During the dormant season the plant can be treated with quite strong preparations of kerosene emulsion, thus destroying a large portion of the mature insects.

Canker Worm, Fall Web Worm, Tent Caterpillar and Bag Worm.

The above leaf-eating larvæ are fairly well known, and belong to that large group of Lepidopterous insects commonly called moths. In the larval state they are voracious eaters, and do great harm to various fruit and ornamental trees.

The first is the well known apple measuring worm, and occurs early in the spring. The larvæ have a very distinct habit of looping up as they crawl over the surface of the plant; they also will, when disturbed, drop a foot or two beneath the branch and hang suspended by a delicate thread. The worms pupate in the ground and the moths appear some in the fall and others early in the spring, there being two species. The females are wingless, and many devices have been tried to prevent them from ascending the tree to oviposit, and some of these measures are successful when attended to with vigilance, but, in careless hands, fail. These methods are not given here, the simpler method being to spray with poison when treating the trees for other purposes, as will be mentioned further on. The arsenical mixtures are used for this species which see under insecticides.

The fall web worm is rather miscalled, as they occur in this latitude during summer, but their well known habit of starting a web out on some branch and gradually extending it over adjacent branches, and in the meantime completely skeletonizing the leaves, sufficiently marks it for practical purposes.

Remedies.—On their first appearance go carefully through the orchard and destroy them when small by cutting off the twigs and crushing the larvæ with the foot, or apply for a moment a lighted torch to the web. Cutting out is perhaps the safest, unless the torch is handled with care. A torch is excellent for use in tall trees. These larvæ can also be treated with arsenites.

The tent caterpillar is a very common insect in this State, and infests wild cherries and other wild fruit trees to a large extent. In the orchards their web is a most unsightly thing, and the careful grower never tolerates them, for their destruction is comparatively an easy matter. The egg masses are closely glued to twigs of the tree by the female moth late in summer. The young larvæ hatch the following spring, just as the leaves appear, and proceed to build a "tent" or silken web, frequently in a crotch or where strong branches are given off. Hence, they are not so easily cut off as the web worm, but, as the larvæ remain in the "tent" most of the day, a careful operation with a heavy stiff brush will despatch them; or they can also be treated with a torch or arsenical poisons.

The bag worm is, indeed, an interesting specimen, because of its ingenuity in building for itself a case which acts as a protection from enemies. It has not often occurred in our experience that these insects have appeared in injurious numbers, but they are quite common in this State. They infest conifers and a number of other forest trees and some fruit trees, and are easily despatched by using arsenites as elsewhere prescribed.

Rose Chafer or Grape Beetle (*Macrodactylus Subspinosus*).

This beetle is commonly spoken of as the rose beetle, rose bug, grape beetle and also by other names. It is a small, snuff-brown beetle, with very long spiny legs, and commonly attacks roses, cherries, apples and grapes. On the last mentioned, it does perhaps the most marked injury, as it customarily appears at the period when the grapes are in bloom, and comes in such great numbers as to wholly destroy the crop unless promptly checked. This insect is especially fond of the grape blooms, and will leave other food plants to attack it. Unfortunately, this is a most difficult species to treat, as it appears in such large numbers and works rapidly.

We have succeeded thus far in holding it in check with the combined Bordeaux and London purple treatment as given under fungicides.

Codlin Moth (*Carpocapsa pomonella*).

This insect in the mature stage is a small moth. Very few growers know it at all in this stage, hence it is quite generally called the "apple worm." The egg is deposited by the female moth in the calyx of the young fruit. It hatches in a few days and penetrates into the core, doing the well-known injury. The apple maggot is an entirely different insect from the above.

Remedies.—There have been many remedies tried for this insect but with little success until some ten years since it was accidentally discovered that the arsenite washes were an almost perfect remedy, since which the use of these washes have rapidly spread. They are now being almost universally employed. They must be applied immediately after the blossoms fall, and repeated if the weather is so rainy that the application is washed off. The aim is to get a small particle of the poison lodged in the calyx end of the fruit before the worm enters, and in this manner poisons it.

General instructions are given under arsenites.

Plum Curculio (*Conotrachelus nenuphar*).

There are two curculios which prey upon the plum, but the one that does much greater harm is here mentioned, and may be always identified by the crescent-shaped slit it cuts in the fruit. This characteristic mark is made by the female in the act of properly placing the egg. The little ash brown beetles are quite inconspicuous, but can readily be found by a little quiet observation. The real injury is done by the larva which lives in the fruit until it is full grown, thus causing the fruit to decay and fall prematurely.

The mature beetles usually appear as soon as the leaves are putting forth and may be found feeding on the tender foliage. However, they feed but slightly.

Remedies.—It is fair to presume that all fruit growers are familiar with the old methods of trapping and jarring the beetles. The methods of jarring, if carefully and persistently worked, are

really the most successful, but laborious. The more recent method of poisoning with arsenites is proving quite successful where intelligently applied and is given under arsenites.

Borers.

There are a considerable number of insects belonging to different orders to which the name "borer," with various modifications, is applied. The principal ones, however, which interest the fruit growers are two beetles, one known as the flat-headed borer (*Chrysobothris femorata*), and the other as the round-headed borer (*Saperda candida*), and the moth, known as the peach tree borer (*Sanninia exitiosa*).

The attack of these several insects is similar, viz.: the females deposit their eggs on the trunk of the tree, usually near the ground, but the flat-headed borer may attack anywhere on the trunk and occasionally on the large branches. The injury done by the grubs or larvæ are well known.

Remedies.—The only direct remedial measure of any consequence is to go carefully over the orchards once or twice a year and cut out the grubs with a sharp knife or destroy them by thrusting a wire into the tunnels they have cut through the soft sap wood. However, preventive measures are probably equally as thorough, more easily applied and better, as they check the larvæ before they enter the tree.

These consist in using various washes and paints on the surface of the tree so that when the young larvæ hatch they will not be able to enter.

Several formulæ are as follows:

1. One pint of carbolic acid.

Two quarts of soap.

Two gallons of water.

Mix thoroughly and apply with a cloth or brush.

2. a. Five pounds caustic potash.

“ “ lard.

Mixed in five gallons of boiling water.

- b. One peck quick lime.

Five gallons hot water.

Slake carefully.

Add *a* and *b* together while hot and mix thoroughly. Dilute to a paste with boiling water and use with a brush.

We have used for the past four years white lead paint as a preventive of borers in the Station orchards, with the best of success. The paint should be made from pure lead and linseed oil, about the same thickness as for outside coating and applied with a brush. This we do in the fall, and thus prevent injury from rabbits and all manner of rodents, which otherwise are liable to do serious injury to young trees. The soil should be dug away from the base of the tree and an examination made for borers; carefully remove any which may be present, with a knife, and scrape the wound clean. The use of a wire is uncertain and ill-advised, so far as peach trees are concerned. After the trunks are dry, brush clean and apply the paint for about two inches below and one foot above the surface of the ground. When it is dry restore and compact the earth. This application will last for one year, and in our experience not one per cent. of the injury commonly occurring, especially from the peach borer, will result. We have had absolutely no injury from apple borers, and very little from the peach borers, and after using this remedy for four years, believe it can be safely recommended. The cost is slight, varying with the skill of the workman, but ought not to exceed one cent per small tree and two cents per large tree per year.

Whatever application is used, to secure good results, it must be thoroughly applied, and of the more temporary washes, two applications are necessary each season.

Potato Beetle (*Doryphora 10-lineata*).

This insect (so well known that almost every child recognizes it), is nevertheless a most persistent pest and causes growers in this State to expend many hundred dollars annually in its destruction. It has no very important animal enemies, hence man alone is compelled to fight it to hold its wonderful fecundity in check.

As a remedial measure, arsenic in some form is now the generally accepted preparation, but there is a great diversity in its manner of use. Under arsenites and under machinery this is spoken of at greater length.

The Striped Cucumber Beetle (*Diabrotica vittata*).

This beetle is closely related to the preceding and is equally common. The two beetles differ, however, very much in habit. The potato beetle does the injury while in the larval stage, the disgusting grub being a voracious eater, but the parent beetle eats very little. The cucumber beetle is a voracious eater in the imago or perfect stage and does the greater part of the injury at this time. Its larvæ are small, light-colored grubs, which live in the ground at the base of the vines, where they do some injury. The principal injury is done, however, by the mature beetle.

These come in great numbers as soon as the plants are out of the ground and will, if not checked, devour the whole plant in short order.

Remedies.—Many remedial measures have been tried for this insect, and a number of them possess some value, but eternal vigilance is the price of success. The plant can be rendered obnoxious to the beetles by dusting with soot, lime or road dust, but at best these are only partial preventives. The writer has used arsenic in dry mixtures with some success. See under arsenites.

When it can be done, the one safe and sure measure is to protect the plants with some sort of covering, such as can be easily constructed by bending wires or slender withes over the hill, after the fashion of double croquet arches, and fastening cheap netting securely over them. The netting must be closely held to the ground by small pegs or in some other manner. If the plants can be protected until the vines begin to "run" there is little further danger.

Flea Beetles (*Haltica* sp.).

There are several species of these minute jumping beetles that are quite destructive to plants.

It is the perfect insect that attacks the plants, and their ravages are by no means limited to a few plants, as every cultivator of experience knows.

The remedy that has proven most effectual in our work is kerosene emulsion, and without discussing the many other remedial measures, this treatment is given under insecticides, which see.

Cabbage Worms (*Pieris* sp. and *Plusia brassicæ*).

There are a number of larvæ, the imagines of which are small butterflies of the genera *Pieris*, and also a very destructive larva of the moth above mentioned (*P. brassicæ*), all of which feed upon growing cabbage. The moth, however, does not occur in very injurious numbers over wide areas. If it did it would rank as the most destructive of all the species infesting cabbage.

The chief pest had in mind when we speak of the cabbage worm is (*Pieris rapæ*) the European cabbage butterfly. This insect is a small butterfly mostly white, fore wings marked with two black dots in the female and one in the male, and shaded at the outer angle.

The larva of this butterfly is of a pale pea green color, and that of the moth mentioned is a still lighter green, with pale longitudinal stripes. The latter loops up its body in a very characteristic manner which readily distinguishes it from the butterfly larvæ. These larvæ all operate in practically the same manner and are treated alike.

Remedies.—Perhaps no insect, except it be the plum curculio, has had more humbug remedies prescribed for it than the first insect mentioned under this head. Their treatment is, however, very simple and comparatively cheap. Pyrethrum powder of good quality is practically a specific for them. Instructions are given for its application under the following section.

The cabbage maggot is an entirely different insect, being the larvæ of a two-winged fly, *Anthomyia brassicæ*. These minute larvæ are very destructive and there is little remedy except to rotate the crop, giving the cabbage fresh soil at least every two years. In the plant beds, or where practical to use it, kerosene emulsion is a good remedy. See emulsion under insecticides.

Club root of cabbage is not caused by an insect, but is the result of a fungus attack. The diseased plants should be burned and the crops rotated.

Currant Worm (*Nematus Ventricosus*).

This worm is the larval stage of a four winged fly, which is but a little larger than a common house fly. The eggs are deposited on the under side of the foliage of the currant and

gooseberry, early in the spring, and from these the larvæ soon hatch. They are green, thickly spotted over with black dots, and the larvæ curl the anal segments under in a peculiar fashion. The insects in the larval stage, are quite well known. There are two or more generations each year.

Remedies.—This insect has been very commonly treated with white Hellebore, in dry preparations, but this method is laborious and it has also been learned that it can be much more efficiently applied in water.—See Hellebore, under insecticides.

Corn Worm or Tomato Fruit Worm (*Heliothis Armiger.*)

This worm is the larva of a moth, its color is pale green to brown, marked with darker longitudinal stripes. It is a voracious feeder, entering the ear and devouring sweet, and often field corn, with an avidity which makes it truly a pest to growers. It is not satisfied, however, to confine its attacks to corn, but is, at times, quite destructive to tomatoes, eating the ripening fruit. It also does much damage to cotton by boring into and destroying the bolls. It is in the latter case called the boll worm.

Remedies.—It is impossible to give any remedy that is satisfactory. Trapping the moths is resorted to, but with doubtful success, and it appears at present to be a case where hand picking is the only remedy of much avail. It is not difficult to detect the presence of the worm in the immature ears as they eat a portion of "silk" before entering, and many times they leave a plainly discernable opening, through which entry was effected. This is one of the cases where no satisfactory remedial application, which is safe, has yet been found. We are, however, using with some success, a strong decoction of tobacco and whale oil soap. This is applied with a sponge or cloth to the silks and outer end of the young ears immediately after the corn has passed the blossom. It must be repeated after ten days in order to be at all effective.

Tomato or Tobacco Worm (*Protoparce Caroltna and other species.*)

This species must not be confounded with the previous because of some similarity of common name. The larvæ of the Sphingid moths, commonly called tobacco worms, tomato worms, horn

worms, etc., are very destructive pests, and like the previous, are difficult to treat successfully.

These insects are, in the mature stage, commonly called "Tobacco flies," "Hawk moths," "Musquito hawks," etc. They are robust moths, swift flyers, and many of them are beautifully colored. It is their habit to come out about dusk and fly until the air becomes quite cool. The eggs are deposited upon their food plants, and the larvæ feed and grow for several weeks before reaching the formidable size often seen. They feed on a number of wild and cultivated plants, but are especially harmful to tobacco and tomatoes.

Remedies.—This is one of the insects not easily overcome with remedial applications; in fact, no very useful remedy is known. They can be poisoned, but this is not easily done. From the danger of injuring the fruits of the tomato and the leaf of the tobacco, it is seldom resorted to. Hand picking is the usual method of the tobacco growers, and is also largely resorted to by tomato growers to keep this insect in check.

A rather novel means of destroying them was brought to my notice by Mr. C. A. Moomaw, of Cloverdale, in this State who stated that he kept a flock of turkeys on purpose to worm the tomato vines. The turkeys are kept up in an inclosure during the night and regularly driven to and kept moving through the fields during the day. He stated that this method proved quite satisfactory to him.

The moths of the several species which infest the tomato and tobacco, are sometimes killed by placing poison in the blossom of the Jamestown weed (*Datura stramonium*) on which the moth is known to feed, by lapping up the secretions of the blossom. The efficacy of this method is founded on the presumption that the female moths are poisoned before egg-laying takes place, which may or may not be true, as satisfactory evidence on this point has not yet been furnished.

In this case we have a very important friendly insect, which does much to hold these worms in check; this is a small four-winged fly, which attacks the worms while they are feeding and deposits a large number of eggs in their bodies. The eggs hatch quickly and the parasitic larvæ feed on the fatty portions of their

host for a period of four to six days, and then issue through the skin and holding themselves on end, spin a pale silken cocoon which is attached to the body of the worm. Worms will often be found nearly covered with these small oblong cocoons. As many as two hundred may occur on a single worm. These should not be destroyed, for though the worm is not killed at once, it cannot complete its growth and is acting as a support to many enemies. The flies issue from the cocoons after a few days and attack other worms.

II. INSECTICIDES.

Of recent years, the study of entomology has received much attention, both from state and national governments, and as a result, our knowledge concerning rational methods of preventing the ravages of injurious species, has been brought down to a fairly well recognized statement of facts. It is not our intention in this bulletin, to discuss at length, the methods or rationale of any particular treatment, but simply to say that remedial measures, to be successful, must rest upon a correct knowledge of the habits and history of the species to be treated. Much is yet heard of peculiar methods and special remedies, but so far as we are aware, most of such talk is pure chicanery. Without attempting to particularize, or mention all the substances which are, or may be, used as insecticides, we shall briefly speak of those which are generally used and regarded as most important.

Food Poisons.

The use of mineral and vegetable poisons, to destroy leaf-eating insects, has come to be so generally recognized by all workers in this field, both practical and experimental, as a safe and proper method of procedure, that we do not stop to discuss the advisability of such use, but state that where used with proper precautions, these poisons are attended with no more danger than the ordinary routine of farm duties.

Arsenical Poisons.—Of mineral poisons, the only one now generally used is arsenic in some of its various forms. The ordinary mineral white arsenic (arsenic trioxide) is seldom used because of several objections, among which are its mechanical condition, lack of color to distinguish it from other ordinary

white powders and its solubility. It is desirable that an arsenical poison should be entirely insoluble in cold water, otherwise it will seriously burn the foliage. The forms of arsenic commonly used, are the arsenite of copper (Paris Green) and the arsenite of calcium, (London Purple). This latter is an impure substance, prepared from the residue in the manufacture of aniline dyes. It is of a somewhat variable composition and efficacy. However, by a few preliminary tests on a small scale, the strength and efficacy of a batch may be determined so as to make its use safe and reliable. It is much cheaper than Paris green and is so much lighter that it will stay in suspension for several hours with but slight precipitation. This latter quality and its distinct color, make it a very desirable form of arsenic for general use, barring the fact that it is also slightly soluble in water, and hence liable to burn foliage if used incautiously. However, by adding a small quantity of lime water to the preparation, this solubility is entirely corrected and it can be used with perfect safety. This powder can be obtained of the Hemingway Co., New York City, at about six or seven cents per pound wholesale, and retails at ten to fifteen cents.

Paris green is the old form of arsenical poison for use against insects. Its use, begun on a small scale more than a score of years since, has constantly increased until now it is sold by tons. At first it was used with dry diluents, such as flour, ashes, lime, plaster, etc., and it is yet so used in this State by many. But in most places the dry preparations are giving way to water suspension mixtures, the general use of which is made possible by the recent improvements in apparatus for applying them. The general verdict is that water preparations are cheaper and better, and answer every purpose to which the dry powders can be put.

Water mixtures can be applied at any time of the day regardless of light winds or dampness of foliage but powders are not so easily used.

The specific gravity of Paris green is such that there is more or less danger in using it in water mixtures. Being nearly three and a third times as heavy as water (3.29 sp. gr.)* the powder

* Professor F. P. Miles, late professor of chemistry in Virginia Agricultural and Mechanical College, kindly determined the specific gravity of the substances in this bulletin.

rapidly settles to the bottom and unless kept constantly agitated, the poison will be applied to some parts of the foliage so strong that severe injury will result. However, in spite of this fact it has long been used in water mixtures with excellent results, barring occasional damage to plants from lack of attention to keep it in suspension. White arsenic is still heavier than Paris green, (sp. gr. 3.69) hence, for this reason, less suited to water suspensions than Paris green.

To practically test the matter of how long these two arsenites (Paris green and London purple) would stay in suspension, water mixtures of both were made, using at the rate of one pound of powder to one hundred gallons of water in each instance and test tubes twelve inches high by one inch in diameter were filled with the mixture in full suspension.

The Paris green fell at once rapidly and was fully half down in five minutes, and after fifteen minutes scarcely a trace could be observed in the liquid.

The London purple was precipitated from the mixture very slowly. After one hour very little of the powder had fallen, and it did not fully precipitate for several hours. A small quantity of either flour or starch when added to the mixture did not affect the Paris green but caused the London purple to precipitate quite rapidly so that in twenty minutes it was practically all down. This clearly shows that it is wrong to advise the addition of flour or starch to London purple mixtures, as it largely increases the danger from unequal distribution of the powder over the foliage.

Prescription.—We make practically no difference in prescribing these two arsenites, though it is true that, used with proper care, the best results are obtained, in our work, with Paris green. London purple for reasons already stated (solubility and non-uniformity) is apt to give less satisfactory results, but with care and some experience it can be safely used and is much cheaper.

Many persons advise its use in less quantities than Paris green because of more severe caustic action, but after considerable experience we generally use it a little stronger if anything than the latter. The caustic effect is controlled, as stated above, by use of lime-water. Use about two gallons to each fifty gallons

of preparation. For water mixtures our usual prescription is one pound of either poison to one hundred gallons of water, or one ounce to six gallons. This mixture is good for most general purposes and if properly applied is usually safe. There is sometimes danger of burning young foliage, but for apples, pears, cherries and plums, it is practically safe. Use the arsenical poisons on the above plants for all insects which eat the tissues.

For peaches it should not be more than one pound to 300 gallons. We do not advise its use on peaches at all.

In the strength advised give the plants a copious treatment, but it should always be in a finely atomized spray. For potatoes, we have found one pound to about seventy-five gallons to be the right quantity when applied with the proper implements. It should be forced among the vines in a fine mist and if the strength is good the work can be done rapidly, as only a very small amount of the mixture is necessary to do the work. With the implements described further on, this work can be done very rapidly and at slight cost after first outlay for machinery.

These general directions, with slight experience, will enable any one to apply the poisons safely. In making water mixtures the powder should always be made into a paste with a small quantity of water and then added to the larger quantity.

In dry mixtures these poisons are also prescribed alike, but I believe that London purple has a greater advantage over Paris green when used in this manner than in the water mixtures. As it is so much more bulky it mixes more readily through a larger mass of diluent, and its particles seem to remain on foliage better than the Paris green. It works better in powder from a bellows, and its color is more marked when distributed through a large mass of diluent.

The directions for mixing dry poisons appear to be very conflicting, some advising many times the diluent that others do. This can, in some measure, be explained by a comparison of the different diluents used. Dry mixtures can not be safely made by weight, unless the relative bulk of the diluents are taken into consideration.

The specific gravity of a few common diluents were kindly determined by Prof. Miles, and are here given: ground gypsum,

or land plaster (2.33); gypsum calcined (plaster Paris), 2.95; wheat flour, 1.37; starch, 1.58. From a comparison of these figures it will readily be seen that ground gypsum or plaster Paris should be used in greater weight than flour or starch to make the same bulk of diluent. This is an important matter, and in recommending these mixtures it should always be borne in mind that it is relative bulk of poison and diluent we want, and not relative weight. Flour has long been a common diluent for use on a small scale and gypsum is the common article in use for work on a large scale. The old prescription was one pound of poison to twenty or thirty pounds of flour, and this has been very successfully used by the writer, but experiments prove that this is much stronger than necessary and often liable to do harm to the tender plants. A better prescription is one pound of poison to forty or fifty pounds of flour, or one pound to one hundred pounds of plaster, carefully mixed and applied with a bellows. The mixing of the dry preparation is a most important matter and if thoroughly done a less amount of poison is made more effective in a large mass of diluent. This is probably best accomplished on a clean, smooth floor. The tools necessary are an iron tooth rake and a shovel. In this manner a large amount can be easily and rapidly mixed.

Much weaker mixtures than here recommended are used, often with good success, but I know these mixtures to be safe on all ordinary plants and believe that attempts to reduce the amount of poison much below this will often result in failure to accomplish the desired end. Though powders are much used in this State, I do not advise them except for work on a small scale.

White Hellebore.—Aside from arsenic, another poison has a limited use in the destruction of insects. This is White Hellebore, the powdered root of *Veratrum abbum*, a common medicinal drug. The use of this drug is generally limited to currant worms, rose slugs and other species of the saw flies.

For the currant worm this remedy is unsurpassed and from the nature of the drug there is less danger to human beings than in the use of mineral poisons, and no danger whatever of injury to the plants treated. It was formerly used dry, either pure or diluted, dusted on after a shower or when the plants were wet

with dew. This method is laborious and often unsatisfactory. Now it is commonly used in water, one ounce being sufficient for about two gallons of water. This strength, thoroughly applied with a force pump and spray nozzle, will destroy all worms and its effects last for some time. If used dry it should be diluted three or four times its bulk and applied with a bellows. The powder loses strength with age.

Remedies Which Kill by Contact.

The remedies of perhaps secondary importance, are those which kill by contact. These are also quite numerous but only a few will be mentioned.

Kerosene Emulsion.—As a remedy of general importance, this undoubtedly stands at the head of this class. Since Dr. Riley first published the formula for this preparation, as worked out in his division, there have been a number of other formulæ published, but so far as we have tested them, they are of minor importance. None of the formulæ we have tried will make as good an emulsion as the one adopted by him in the work of the Entomological Division, nor are they easier to prepare. Although much has been said and written about this remedy, it is yet very little understood by the public at large. Its successful use is rather restricted. It will kill tender larvæ if applied sufficiently strong, but with all ordinary leaf-eating insects the strength required to do sure work, will destroy or seriously injure many plants, hence we conclude that its chief use is for the plant lice (*Aphididae*), and bark lice (*Coccididae*), and other Hemipterous insects. Here it has a wide field of usefulness, and by thorough application, it may be made, with care, to destroy most of the injurious species of this order where they can be reached with liquid remedies. It is also a very useful remedy for applying about the roots of plants to destroy tender larvæ and upon domestic animals to destroy lice.

The following formula is the one referred to above, and is always used in our work and considered the standard preparation:

Kerosene, 2 gallons, 65 per cent.	
Whale Oil Soap, $\frac{1}{2}$ -pound,	} 35 per cent.
Water, 1 gallon.	

Bring the soap into solution by heating for some time in the water, and then when boiling hot remove from the fire and add the kerosene. Churn while hot with one of the small pumps illustrated at Fig. 1, by pumping it rapidly back upon itself. The mixture will expand about one-fourth its bulk and form a creamy emulsion in five to fifteen minutes. When done, it adheres to the surface of glass without oiliness. This preparation will keep, if well made, for a long time, and sealed up, will keep almost indefinitely. When wanted for use it should be diluted with water as required. The strength to be used varies with the purpose had in view. For very tender plants it should be used one part emulsion to 25 or 30 parts of water. This strength will kill plant lice (Aphids) in most cases, if applied thoroughly. On all fruit trees and most vegetables it can be applied much stronger. One part of emulsion to ten of water makes a strong wash, and can be used with safety on the more hardy plants if applied in a light well diffused spray. This strength will surely kill all plant lice and many of the scale insects (Coccids), especially when in the immature condition. The adult scales are difficult to destroy, and we have even failed to entirely destroy some of them with a mixture of one part emulsion to three of water. It is a singular fact that peach trees, which are sensitive to arsenical preparations, withstood this latter without apparent injury. For use in the soil it should never be made weaker than one part to ten, and may in most cases be safely used stronger. It must be applied abundantly and well washed in with water to accomplish much good. This will undoubtedly destroy root lice, but it is a difficult matter to reach them when beneath the surface. For the apple root louse it appears to be the better plan to watch for and thoroughly treat the aerial form when it settles on the trunks.

The above general directions will enable most persons, after some personal experience to safely use this remedy.

Fish-Oil Soap.—Another excellent simple remedy for plant lice is soapsuds. Any strong suds will be quite efficacious, but there are special preparations of soap which are more serviceable than others. The following devised in our work has been used with good results, and is cheap:

Strong concentrated lye (potash), 1 pound.

Fish oil, 3 pints.

Water (soft or rain water), 2 gallons.

Boil about two hours and fill up to two gallons when done. If one gallon of tobacco decoction is used in lieu of one gallon of the water, the soap is rendered more effective. This decoction is easily made by boiling tobacco stems or waste, using about one pound to a gallon of water. The soap prepared as above will keep a long time, but should not be allowed to dry out. When desired for use a suds should be made with soft water, using one pound of soap to eight gallons. This preparation is safer for tender plants than kerosene emulsion. The material used costs about one cent per pound of soap.

Pyrethrum Powder.—This powder is made by grinding up the dried blossoms of several species of *Pyrethrum*, but principally from *Pyrethrum roseum* and *Pyrethrum cinerariæfolium*.

It is known under many names in the trade, as Dalmatian insect powder, Persian insect powder, Buhach, etc., etc. In fact, this powder forms the basis of most of the non-poisonous powder preparations put up and offered by the trade for use indoors and on insects generally. The powder, as it reaches the consumer under these various special names, is very generally adulterated and often worthless. If the consumer can buy pure *Pyrethrum* powder of a reliable dealer, he is sure of getting a very useful article. The imported powder can usually be purchased in New York City of good quality. The price ranges from 40 to 75 cents per pound, according to demand and quality. Lehn & Fink, New York City, are reliable dealers, and it would pay large growers of cabbage to club together and purchase by the wholesale. The home grown powder is known as Buhach, and is largely grown by the Buhach Producing and Manufacturing Company, Stockton, Cal. If this powder can be obtained in unbroken packages, it is sure to be of good quality, but it costs more than the imported article. Jas. L. Barbour & Sons, No. 616 Pennsylvania avenue, N. W., Washington, D. C., handle this powder.

Pyrethrum is non-poisonous to the higher forms of life (vertebrate animals), hence may be used fearlessly about the house, or

on the most succulent vegetables. Its deleterious effect on insect life is caused by a very volatile oil which attacks the nervous system of insects, producing paralysis and death.

It is used pure and diluted. Good powder may safely be diluted four or five times for use on cabbage worms. It has little or no effect on woolly larvæ, and in fact its use in field work is generally limited to cabbage worms. Many other larvæ are effected by it and may be partially destroyed, but as yet we have failed to accomplish practical results. Indoors it is used for various pests about the house, as fleas, bed-bugs, flies, roaches, ants, etc. Flour is the best diluent. It should be mixed and let stand in a closed vessel for some hours before it is wanted for use. The application is best made with a powder bellows, some of the best of which will be mentioned further on. Powder exposed for a considerable length of time loses its strength. We have not had good results with *Pyrethrum* in water preparations, hence do not recommend them.

III. DISEASES OF PLANTS.

Diseases of cultivated plants have but recently attracted serious attention in this country, though they have existed as long as the plants they infest, so far as we have any knowledge to the contrary. Yet it is only within the last few years that the destruction of fruits, grains and vegetables, by parasitic organisms has been of such general occurrence in America, as to attract attention from the National and various State governments. Now their suppression and control have become one of the economic questions, with which almost every community must deal. This increased economic importance has also given a great impetus to scientific study, and much new information has been added to this obscure field of research.

Diseases in the vegetable kingdom, are the results of definite cause, just the same as in the animal kingdom, and where those causes can be clearly ascertained, in most cases, some measure of prevention or control is possible. The organisms causing these diseases, are lower forms of vegetable life, parasitic fungi and bacteria, which grow and multiply upon or within their respective hosts and produce specific diseases.

It is absolutely necessary that the cultivator should learn to regard these minute and very obscure parasitic forms as true plants, vegetable forms, capable of growing, seeding, and reproducing their kind with as much certainty as a kernel of wheat or corn, and with many thousand fold greater rapidity. For without this conception of them and a general knowledge of their life history, he cannot help but feel that he is struggling in the dark with an unknown enemy.

With these brief introductory remarks, we will proceed to mention in a popular manner some of the more important diseases.

In Bulletins 15 and 17, April and June, 1892, we treated of several diseases of grapes and apples, and we shall here refer but briefly to the same diseases again, and others of like nature affecting cherry, plum, pear and peach trees. The five orchard fruits mentioned above, and grapes, comprise the important fruits at present grown in Virginia. Each fruit, with several of its most important parasitic diseases, will be mentioned separately.

Apple.

The apple orchards of the State suffer chiefly from two serious diseases of the foliage, viz: Brown spot (*Phyllosticta pirina*) and Rust (*Gymnosporangium macropus*), which also occurs slightly on the fruit; and two very serious diseases of the fruit, viz: Scab (*Fusicladium dendriticum*) and Bitter rot (*Gloeosporium fructigenum*). These four diseases were popularly described in Bulletin 17, above mentioned, and we will not further treat of them here, except to mention that during the past year we have worked the life history of the bitter rot much more fully than heretofore, and a technical bulletin dealing with this subject, is in course of preparation, and will be issued soon. The above diseases are referred to here, because they are of such prime importance to growers, that we wish to speak of them under head of remedies.

Cherry.

But two diseases of the cherry will be mentioned at this time; one affecting both the fruit and foliage and the other the foliage. The one serious disease of the fruit of cherries is the Brown rot

(*Monilia fructigena*), which causes the fruit to decay just before or at maturity. To all appearances the fruit may be healthy until it begins to ripen, and then suddenly the entire crop will be destroyed, the fruit becoming a brown rotten mass, often adhering to the stems for some time after it is entirely decayed. This is caused by a fungus which has really been present on the twigs, blossoms and foliage all the season. The spores or seeds of this parasite pass the winter season upon decayed fruit and also upon the twigs of the tree, and at first appearance of growth in the spring they develop upon the twigs, petals of the blossoms, and the young foliage, causing blackened decayed patches, and then later transfer their attack to the fruit. This latter is where the real harm is done, and is the only stage of the parasites' existence commonly noticed by growers. No disease of fruits is more widespread or destructive than this one, attacking, as it does, cherries, plums and peaches.

The rational of treatment must look first to destroying the source of infection so far as possible, and this implies the destruction of all the mummied fruit adhering especially to peach and plum trees, and washing the trees while yet dormant with preparations which will destroy the spores lodged upon the trees.

All remedial measures of the nature of washes will be treated together under another section to avoid repetition.

Another disease of the cherry, occurring only on the leaf and doing considerable damage if left unchecked, is the Brown spot, of the leaf which appears from our present study to be identical with the Brown spot of the apple leaf, which has been more fully spoken of in Bulletin 17 above referred to. The treatment for this is the same as for previous, with the additional suggestion that as the leaves are the source of infection in this case, it is best to burn them where this can be done.

Plum.

The plum is very seriously attacked by the Brown rot mentioned above and in the same manner, hence further mention is unnecessary except to say the dried fruits hang upon the plum more tenaciously than on the cherry, and are the greatest source of danger to each succeeding crop.

Perhaps the most serious disease of the plum is Black knot (*Plowrightia morbosa*), which may attack the stems and branches at any point, but more frequently occurs on the twigs of grown trees. The occurrence of this parasite is characterized by a swelling which bursts through the bark and develops a dark knotted growth, causing the twigs in many cases to become several times their normal diameter. None can fail to detect this disease by the abnormal knotted appearance just mentioned. Wherever it occurs treatment should begin at once. If on the twigs, they should be cut away some distance below the growth and burned; if on the larger limbs or trunk, cut away the growth as much as possible, and treat thoroughly with a wash of standard kerosene emulsion diluted five times with water. Should subsequent growth occur treat it again thoroughly. Disinfect the knife used on a diseased tree before cutting others not diseased.

This disease is not difficult to control if taken in its incipency, but after a tree is badly affected, the proper thing is to cut it down and burn it up. Its spread is not rapid, and any intelligent man can control it readily. But an important point here to be considered is that one is always in danger from less careful neighbors, and, without a law compelling all to treat this disease, intelligent growers must suffer from the shiftlessness of others.

The plum foliage is attacked by one right serious disease in this State known as the Shot-hole fungus (*Septoria cerasina*), named from its effect in causing small circular areas to die and drop out of the leaf. In some instances this nearly defoliates the trees early in the season. The same parasite also attacks the peach, and does more injury than on the plum. This disease is likely to appear as soon as the foliage is about full formed, and it develops rapidly, repeating the infection about every ten to fifteen days, especially on peach.

We have found this a serious disease, and it does not yield readily to treatment. However, we controlled it so as not to lose the crop, by spraying with Bordeaux as hereafter given. When trees are badly affected jarring will bring down the leaves, and if these can then be raked and burned at once, it will help much in controlling further infection.

Peach.

The worst diseases of the peach in this State caused by fungi, have been mentioned above—viz.: Brown rot and Shot hole, and nothing further need be added at this time concerning them. Another disease of the foliage which occurs in early spring, is known as Leaf curl (*Taphrina deformans*), and causes some damage, but not great when the trees have been properly treated as given under fungicides.

The disease of the peach which outranks all others in importance, is popularly known as the Yellows, and is caused, so far as is at present known, by a bacterium, a still lower form of plant life than the fungi. This is a very obscure disease, and a full knowledge of it is still wanting. The results, however, are only too well known to peach growers in almost every portion of the eastern United States and Canada. This disease attacks trees at any age, in the nursery row or bearing trees in the orchard, and under all circumstances the death of the trees is inevitable. No tree, so far as competent observation goes, has ever been cured of the Yellows. Hence, the only alternative is to dig out and burn, root and branch, all diseased trees as soon as the malady can be identified. Ground once contaminated ought not to be used for peach trees again for several years.

The writer prepared a law at the request of the peach growers some three years since, providing for inspection and destruction of trees diseased with Yellows, which was, with some modifications, passed by the Assembly. Unfortunately, these modifications made the law quite impossible of execution, and it is a dead letter upon the statutes. In the meantime, this disease has continued to spread over some of our best peach-growing districts and done immense harm. Unless growers are quite isolated from each other, it will be impossible for careful growers to combat this disease when exposed constantly to contamination from less careful neighbors.

The first symptoms of Yellows is usually marked by premature ripening of the fruit and a discolored condition of its flesh, showing rays of brighter color radiating out from the pit. Secondary symptoms are characteristic growths of twigs in which

they become slender and willowy, grow rapidly and start secondary twigs from the leaf axils, until a clump of slender brush-like twigs are, in the advanced stages of the disease, clustered together. The leaves on these diseased twigs are long and narrow, and usually yellowish in appearance. It requires some training to detect the disease readily, but any intelligent cultivator can soon acquire this if he is disposed to be observant.

Pear.

The pear is also affected by a serious bacterial disease, for which there is no known remedy, viz; the blight, or often called fire-blight. The latter is a good name, so far as expressing what appears to occur, as the branches affected look as though blighted by fire. This malady may appear suddenly on one or several branches of a tree, and not recur again for some time, hence the death of the tree attacked is not usually sudden, nor is it certain, for if the diseased portion is promptly cut away, it may not recur again. The proper thing is to remove all diseased parts soon as noticed, cutting them away some distance below the diseased area, and destroy them. The tool used should not be cut into a healthy tree until it has been disinfected.

A second disease of the pear commonly called leaf blight, or cracking of the pear is caused by a fungus (*Entomosporium maculatum*), and affects both foliage and fruit. This is really the most serious disease of the pear we have noticed in this State. It attacks the foliage when first put forth, often before it attains the size of a twenty-five cent piece, and shows as bright carmine spots, on both the foliage and young wood. Later the diseased areas become brown and blackened and have a raised, blister-like appearance on the upper side of the leaf. Reinfections occur at periods of ten to twenty days, and the trees are often entirely stripped of foliage. The fruit shows a scabbed appearance, accompanied by deep cracks into the tissue. Fortunately, this disease can be quite readily controlled with remedial agencies, which will be mentioned under Fungicides. The scab of the fruit of the pear, is very similar to scab of apple and is treated in the same manner as the above. We have not found it serious in this State.

Grape.

The four serious diseases of the grape in this State, were mentioned in Bulletin 15, without discussing them in a critical manner, as that bulletin was designed to treat of remedial agencies. And in the present instance, it is unnecessary to speak of these further than to aid growers, not already familiar, in recognizing them.

The black rot (*Laestadia Bidwellii*) is without question the most serious. It attacks both foliage and fruit, however, in our experience, occurring but slightly on the foliage, and were it not for injury to the fruit, would require little notice. On the foliage it is liable to occur as soon as the leaves appear, and will normally complete one generation before the fruit is attacked. The appearance on the leaves, is in small, nearly circular areas, which take on a brick red color and show minute black pustules scattered over the diseased spot. On the fruit the infection is first marked by a pale spot, usually circular, which becomes sunken and shows clearly that decay is going on in the tissues of the berry. The fruit rots rapidly and a few days suffices, under unfavorable conditions, to ruin the crop. The berries dry up, adhere quite firmly to the pedicels, are of black color, and are covered with minute pustules which can be plainly seen with the unaided eye. These decayed fruits are the chief source of infection the coming season, hence it follows that they should be destroyed.

This disease has caused a very large amount of damage to grape growers all over the country, but fortunately, it can now be controlled with considerable certainty.

The anthracnose of the grape, caused by a fungus (*Sphaceloma ampelinum*), attacks chiefly the canes, but also the fruit. It has not been injurious in our vineyards, but does some injury elsewhere in the State. Its occurrence on both cane and fruit is marked by a sunken scarred area with roughened borders and of a dark color. The fruit does not rot from this disease and will often persist on the bunch until ripened, but it is injured and worthless. Direct remedies or preventive measures, for this disease, are not so certain as for black rot, but we believe the washes recommended do reduce its occurrence.

What is known as the Brown rot or downy mildew of the grape, does its chief harm in our experience to the foliage, where it has often been spoken of as the downy mildew. This is caused by a fungus (*Peronospora viticola*), which attacks the foliage and grows in its tissue, but on fruiting sends minute thread-like branches through the stomata (breathing pores) of the leaf, on the under side, and these there bear an immense number of spores. These spores reinfect foliage and fruit. Its principal injury to the fruit, has occurred in our experience on stored grapes. The remedies employed for black rot, effectually control this parasite.

Powdery mildew of the grape foliage, is caused by a surface parasite (*Uncinula Spiralis*) which has in the past done some considerable harm, but now it is easily held in check by the general treatment given under fungicides.

IV. FUNGICIDES.

Before treating specifically of the preparations which are used with more or less efficacy in the treatment of plant diseases, it may be well to repeat an oft reiterated statement made by writers on this subject, that treatment is preventive, not remedial. There are no remedial agencies which will reach the parasite in the tissues of the host without destroying the host also. However, it is possible often to allay or prevent in some measure the further spread of a parasite after the host is infested, but there is no cure for the evil already done only so far as assisted nature may be able to restore it. It is also equally important to know that a large part of preventive treatment consists in what may be justly called sanitary measures, *i. e.* those operations which fortify the vigor of the plant and remove infective material. In this category come such operations as properly enriching and cultivating the soil, drainage, pruning, training, destruction of diseased leaves and fruit, etc.

Most of these items belong to the art of horticulture and are only alluded to here. However, all may as well understand that they are the first essentials to success.

For the bacterial diseases mentioned in a former section of this bulletin (Blight or fire blight of the pear, and peach Yellows), we have already stated that there are no remedial measures possible. Destruction of the plants affected with blight, or of the diseased parts, is all that can be done. But for all the other diseases mentioned, both of plant body, foliage and fruit, there are preventive agencies which may be employed with considerable certainty, provided it is always understood that thoroughness and experience are necessary to the best results.

In every case of fungus disease of the plants mentioned in the preceding section except one, infective material remains in the orchard or vineyard either on the stems, twigs, leaves or fruits as the case may be. This one exception is the apple rust, which was treated more fully in Bulletin 17, of this Station. In this instance the infection comes each spring from what are popularly called cedar apples, large abnormal, nut-like growths on red cedar. In April or May these balls or apples put forth numerous ray-like yellow masses in which the spores are borne that infect the apple foliage. From this it will be at once evident that cedars should not be permitted to grow in proximity to the orchard, and in fact the spores will float long distances. It is not a light matter to attempt to destroy the cedars but it should be done so far as possible. However, in our work here we have effectually prevented this disease with the common treatment hereafter recommended.

The infective material in the way of leaves and decayed fruit resulting from the other diseases mentioned in the former section, can and should be destroyed either in the fall or very early spring. This having been done, our general treatment is as follows, for all the fruits mentioned: Just before the buds begin to open, the trees and the vineyard are sprayed thoroughly with either a solution of concentrated lye or copper sulphate. In our opinion the lye is the best but is more unpleasant to use than the copper sulphate.

Formulæ :

I. Concentrated lye, eight cans.

Water, fifty gallons.

Or, what is better, use a Beaumé acid spindle and make the lye strong enough to register three degrees.

II. Copper sulphate, two pounds.

Water, fifty gallons.

One or the other of these should always be applied in a copious manner with a spray pump.

We have used for this first treatment saturated solution of sulphate of iron, preparations of lime, kerosene emulsion and other substances, but find the two recommended above the best for general purposes. The lye is especially good to clean up the trunks and branches of fruit trees, and for such parasites as the apple seab, appears to destroy the hibernating mycelium on the twigs. It has worked a marvel in an old orchard standing on the Station grounds. Either of the above preparations will destroy the young foliage if applied after it has appeared.

The preliminary treatment is alike for all the fruits mentioned, but from this on there is a slight divergence in the treatment according to what object may be had in view. We treat all the orchard fruits with weak Bordeaux mixture just as the bloom falls, and, in fact, for those attacked with brown rot, it is well to apply this treatment at full bloom, so as to check the development of the parasite upon the petals of the blossoms. This treatment with us acts equally well for all the leaf diseases mentioned, including those affecting the fruits also, as apple seab and brown rot. Immediately following bloom, when there is a rapid development of young foliage, it is extremely important to keep it well protected, hence the treatment must soon be repeated. Climatic conditions, as temperature, storms, etc., will affect this somewhat, but it is best not to wait longer than ten days before repeating the treatment, and we again use Bordeaux for all the fungoid diseases mentioned. From this period it is still a question with us what recommendation is best. Bordeaux has, in some instances, done injury to the fruit, corroding and affecting its smoothness, but at other times no such ill effects have appeared. We consider it more effective and lasting than any treatment now in use, but there is another preparation of copper which is quite effective, and can be used without burning or injuring the fruit. This is the ammonia-copper carbonate

given in the formula below. Peaches and plums have shown no ill effects from Bordeaux with us, but apples and pears are at times affected by it. We think from our present knowledge that the ammonia preparation is the safer for the fruit grower, and would probably better be used for applications to the orchard fruits subsequent to the second treatment mentioned above.

The third treatment may, under ordinary conditions, be delayed fifteen or twenty days after the second, and should then be most thoroughly applied. This should suffice for rust and scab of the apple, brown rot of the stone fruits, shot-hole fungus, scab of the pear, and many other minor diseases not mentioned. But we have found brown spot of the apple leaf and leaf blight, or cracking of the pear, to be very persistent. These must be watched and treatment repeated promptly should they reappear.

The bitter rot of the apple does not make its appearance until the fruit approaches maturity, hence treatment should be delayed accordingly. Here it does not appear on any varieties until after the middle of July, and is not bad until late in August, but this matter must be settled by local observation for each section. The first treatment for it should be made just prior to its customary time of appearance, and should it subsequently be found attacking the fruit, repeat the treatment promptly. Use the ammonia-carbonate of copper. Two thorough treatments are perhaps all that will be necessary. This is a serious disease, but it can be controlled by the preparations recommended.

The treatments for grapes are somewhat differently timed as to first applications. After the preliminary treatment with lye or copper sulphate, prescribed above, we apply Bordeaux when the young shoots are six to eight inches long, and again just at or before full bloom. Thus counting the preliminary treatment, the vines have had three treatments at period of full bloom. These early treatments are of extreme importance, and, if properly done, lessen very much the necessity for late treatments. About fifteen days after blooming a fourth treatment should be applied. This is really the third application of Bordeaux, and with us has proven sufficient to save Concords, Ives and Nortons almost perfectly. With Concords there is the greater danger. However, there is greater security from rot, where the disease occurs

with severity, if a fourth application of Bordeaux is made about twenty days later. This we consider ample for all purposes.

While black rot is really the ostensible object of the treatment prescribed, it meets the requirements necessary to hold the other diseases in check also.

FORMULÆ OF PREPARATIONS.

1. Weak Bordeaux—

Copper sulphate (bluestone) 4 pounds.

Lime (unslaked), 5 pounds.

Water, 50 gallons.

2. Ammonia-copper carbonate—

Copper carbonate, 6 ounces.

Ammonia 26° B., 2 quarts.

Water, 50 gallons.

To prevent the latter having any caustic effect, especially on young peach foliage, use one or two gallons of strong lime water to fifty gallons of preparation.

We still use the soda-copper preparations, published in former bulletins, in our work for the same purposes as Bordeaux, and think highly of it. The formula is as follows:

3. Soda-copper preparation—

Sulphate of copper, 4 pounds.

Soda carbonate, 5 pounds.

Water, 50 gallons.

This preparation works more easily through spray nozzles than Bordeaux, and with us gives about the same results.

Combined Insecticide and Fungicide.—It is important here to speak of a combination of insecticide and fungicide commonly used by us, as by this means we avoid the labor of duplicate treatments on such plants as require both. This combined preparation is used on the apple, pear, plum and cherry, for the insects liable to infest them, as given under another section of this bulletin, and on grapes for the rose chafer, or "rose bug." It consists in adding to each 50 gallons of Bordeaux, one-half pound of London purple. We use this for the first two applications on orchard fruits mentioned, and on grapes at time of blooming. Note what is said on use of arsenic on peaches,

under head of insecticides. This combined treatment has fully answered in keeping down the injury from codlin moth of apples, the leaf-eating insects mentioned in a previous section, and the rose chafer on the grapes, and also checks numerous other insects.

Preparation of Fungicides.—For Bordeaux preparations, the copper and lime are conveniently treated as follows: Suspend each in separate tubs or casks in a coarse gunny sack and allow them to remain immersed in water several hours or a day. The ingredients are thus brought into solution and strained at the same time. When ready to mix, pour the two ingredients into a fifty gallon cask and fill up with water. They can be dissolved in the tubs without the use of sacks, but we have found their use to be convenient and serviceable, as the preparations are already quite well strained. Copper-soda preparations can be handled in the same manner. These chemicals corrode ordinary metals rapidly, hence wooden vessels should be used. The ammonia-copper carbonate is most easily prepared by first moistening the carbonate and then adding the ammonia. Strong ammonia should be handled with care and this preparation must be kept tightly bottled and diluted as wanted or else prepared just as needed. There will be a small residuum of the carbonate which will not dissolve.

V. MACHINERY FOR USING INSECTICIDES AND FUNGICIDES.

The implements necessary for the proper application of fungicides and insecticides are, for water preparations, pumps and syringes; for powder preparations, bellows and dust cans. Syringes are only of importance for green-houses and small work, hence we shall only notice them to say that the best styles are made by Robert Deakin, Philadelphia, Pa. Good pumps and spray nozzles are the all-important apparatus for outdoor work, as nearly all applications are now made in the form of spray. Briefly stated, the pumps should be light, strong and durable, and be capable of furnishing from 30 to 60 pounds of pressure on the discharge pipe.

The old forms of cast-iron pumps are now going out of use, and are being very generally supplanted by the style of which

the Aquapult, illustrated at figure 1, is the type. This pump is composed of two cylinders, one working within the other and of such relative diameter that the inner or piston cylinder displaces on the downward stroke the same quantity of water it lifts on the upward stroke, hence making it double acting. The water is taken up through a valve in the lower end of the outer cylinder and passes up through a like valve at the bottom of the piston cylinder, and is discharged near the top of the outer cylinder. This style of pump is manufactured by several firms in the United States, and there is no patent on it, hence we feel at perfect liberty to recommend it as the best in general use for heavy work of any style now made in this country.

The Aquapult, figure 1, is made by W. & B. Douglas, Middletown, Conn. It is the first pump of this pattern which ever came to my notice, and though a small pump used from a bucket is very serviceable. I take off the short hose and put on one of one-quarter inch cloth insertion tubing ten feet long, and use an improved nozzle, some of which will be mentioned below.

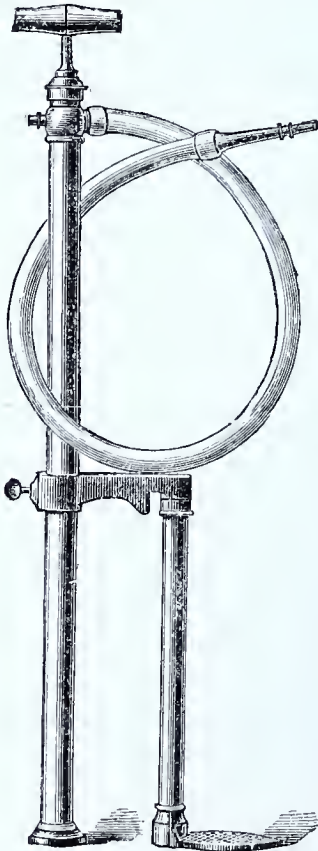


FIGURE 1, AQUAPULT PUMP.

Fitted as described, this pump will answer every purpose for spraying small orchards, etc., but is not to be compared with the larger apparatus of the same style for heavy work. This small pump is well suited for mixing emulsion as described in another section of this bulletin.

The Nixon Nozzle and Machine Co., of Dayton, O., manufacture several styles of the aquapult pump suited for heavy work in spraying insecticides and fungicides, one of which we illustrate below. The best style of pump for general use manufactured by the Nixon Co., is mounted on a tripod, in the manner illustrated at Fig. 2. Our principal reason for illustrating this style, is to suggest to growers how easily they can, by a little ingenuity, rig such a pump to a barrel home-made tank, and thus provide themselves with a first-class outfit.

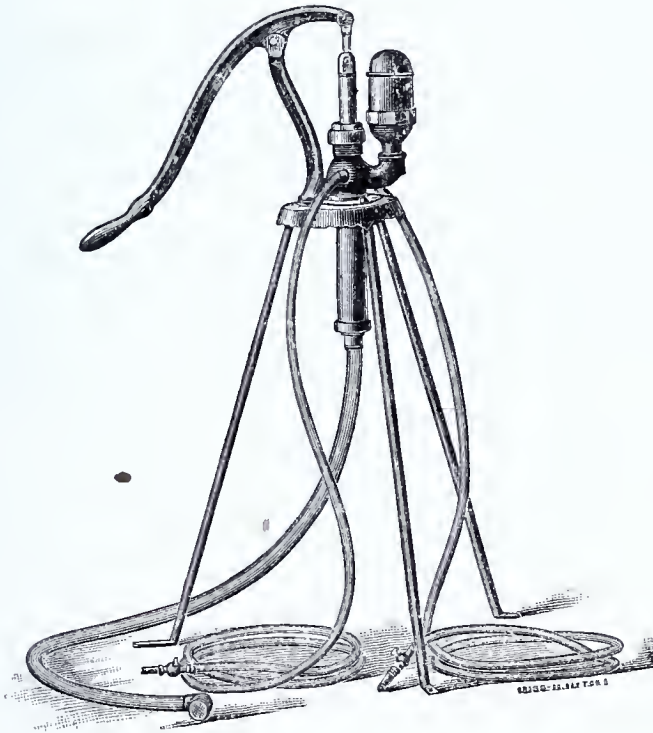


FIGURE 2, LARGE AQUAPULT PUMP.

This pump has two discharge orifices, and is capable of throwing two continuous streams of spray. We use a pump like this, rigged with a movable head on a barrel, and with it

mounted on a wagon, treat our orchards quite rapidly. One man pumps and drives, while another handles the discharge pipe. For lightness and convenience, we use one-quarter inch cloth insertion rubber tubing for a discharge pipe. This should be about twenty-five feet long for large orchard trees, so as to give the operator freedom of movement. A light rod or bamboo pole is a great convenience, and really a necessity for elevating the nozzle to properly treat large trees.

For low growing crops like potatoes, there are now manufactured several styles of geared machines, which do their work rapidly and well. The Nixon Company manufacture one which we have found to work well; it sprays three rows as fast as a horse will walk, is adjustable to any ordinary distance of row, and may be made to spray four rows if desired. At this speed thirty acres may be sprayed in a day, and it requires but one man and a horse to do the work. This machine will also deliver a broadcast spray in the rear for any general purpose and a continuous spray overhead for fruit tree work, if desired. However, we do not consider this latter practicable. The pressure is regulated by a safety valve.

Knapsack Pumps.—These are very important styles of apparatus for low crops and vineyard work. They are portable, one man carrying and working the whole concern. These were first introduced into this country from France by the Division of Vegetable Pathology, U. S. Department Agriculture, and are now manufactured by several firms whose addresses are given below. We have tested carefully almost all the styles made, both in this country and in Europe, and decidedly prefer the Japy type of pump. This pump is very simple in construction, and works easily. The principal feature in its construction, which renders it, to our notion, better than others is, first of all, that it has what is known in France as the Letestu piston, which no other style of pump so far as we know uses, and its working parts are so fitted that they can be removed from the tank in a few minutes time without tools or trouble. Hence cleaning or repairs are easily attended to. We have had the French type of this pump altered in several points, and our modification is now made and sold in this country as the American Japy. The

manufacturers are Robert Leitch & Sons, Washington, D. C., and for all practical purposes we recommend this pump as most likely to give satisfaction. A good strong hand can spray from three to five acres per day, with one of these pumps and do excellent work.

Spray Nozzles.—There are so many spray nozzles, that we will not even attempt to enumerate them. In our work we use only the Riley or Cyclone, and the Climax nozzles. The first of these is now well known but not in such general use, as its merits warrant. For many purposes it is unexcelled and has been quite generally adopted for fungicide work in Europe, as well as in America. The modification known as the Vermorel, is the best style for general purposes, and it is manufactured either with the nozzle by itself fitted with a degorger or with a special lance with thumb lance degorger. We advise the first for use on large pumps with long discharge pipes and the second for use on Knapsack pumps. The climax nozzle is made by the Nixon Company, and is a good general purpose nozzle now rapidly coming into use. It will not spray heavy preparations like Bordeaux mixture.

Bellows.—There are numerous forms of bellows, all of pretty much the same style, i. e., with the powder box or receptacle, situated on the blast or discharge pipe. Most of these are perfectly worthless. Woodason's double cone style is about the only one that can be used with any satisfaction. His address is Thos. Woodason, Philadelphia, Pa. In the matter of bellows, as in that of knapsack or portable pumps, the French make very superior implements to ours. The Department of Agriculture has imported several styles of these bellows, and some of them have been illustrated in reports from the Department. I shall speak of but two of these, the Lagleyse and the Francaise. The first named is made by J. Serre's Sons, and the other by Malbec & Gilloux, both of Beziers, France. They operate on the same principle and are practically alike. These bellows are so radically different in construction, from anything made in this country, that they deserve especial mention. Instead of the powder can being placed on the discharge pipe, out beyond the body of the bellows, it is situated on one of the leaves close up to the hand. The can has a false bottom or cross septum of per-

forated tin or fine wire cloth situated about an inch above the true bottom. On this septum the powder rests and is fed through in the Lagleyse by rotating arms working above this perforated plate, and in the Francaise the septum itself, which is of wire cloth, rotates. The rotation is accomplished by means of a bent wire rod, which passes up through the center of the bottom of the can and is fastened in the center of the rotating arms or the wire-cloth plate, as the case may be. This rod is bent at right angles below the bottom of the can, and linked into another like rod which is connected to the opposite side of the bellows. The bellows opens sufficiently wide to rotate the agitators, or feed plate, one-fourth around at each oscillation. This keeps up a constant feed of finely sifted powder. The blast is delivered into the can below the feed plate and constantly catches and carries out a finely diffused mass of powder. These bellows are so superior to the old style that when once used, one cannot do without them. Mr. W. M. Effinger, of this place, manufactures them in a small way, for such of our correspondents as desire them.

The following firms are manufacturers of general spray machinery, and all intending purchasers will do well to write them :

Robert Leitch & Sons, Washington, D. C., (American Japy knapsack pumps, and cyclone nozzles.)

W. & B. Douglas, Middletown, Conn.

The Gould's Company, Seneca Falls, N. Y.

Field Force Pump Company, Lockport, N. Y.

Nixon Nozzle and Machine Company, Dayton, O.

The last four firms manufacture a general line of implements.

WM. B. ALWOOD,

Horticulturist, etc.